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RURAL ELECTRIFICATION AND RURAL DEVELOPMENT

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RURAL ELECTRIFICATION AND RURAL DEVELOPMENT *

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INTRODUCTION

1. Rural electrification in less developed countries is widely viewed by development policy-makers, planners and administrators as essential to rural development. The validity of this view obviously depends upon what is included in the term "rural development" -is it the development of the small village, the cluster of villages, or the market town? Is it the development of a large area such as the block in India, or an entire region like the Cauca River Valley in Colombia, encompassing parallel programs of agricultural modernization and industrial decentralization? Does rural development include social improvements resulting from the provision of such amenities as illumination, radios and refrigeration? The critical question is: "electrification for what specific purposes?"

2. This paper examines the relationship between rural electrification and rural development by considering the role and socio-economic significance of small power generating units in the development of village communities, and alternative approaches to relating rural electrification projects to viable rural development opportunities. It is clear that the productive use of electricity in rural areas depends upon effective load-building programs integrated with rural electrification programs.

SMALL SCALE POWER UNITS FOR VILLAGE DEVELOPMENT

Electrical Energy Generation

3. Field investigations were carried out recently in rural areas of India, Colombia, Chile and Peru to assess the need for and the impact of electrification on rural development. At the outset it was hypothesized that a small scale engine generator capable of utilizing a variety of indigenous fuels would be an effective and economical means of supplying from ten to fifteen kilowatts of electric power to rural villages. This hypothesis was not borne out in either India or Latin America from the generation or productive utilization standpoints.

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4. In the limited number of instances where it was judged that the local generation of electrical energy could make a productive contribution at the village level (population 2000-3000), the field studies showed that a 50 Kw unit would be the minimum size required. In addition, it would be advisable at the outset to install excess capacity for future load growth. Further, some reserve or standby capacity should be provided to assure a dependable supply. These requirements are well above those originally estimated, and have substantial implications for the alternative fuels that can be considered.

5. It was found that, in practically every case, supplies of local fuels such as wood, rice hulls, dung, straw, leaves, etc., were insufficient to meet the daily requirements of an engine-generator of adequate size on a dependable basis. Figure I shows the estimated daily fuel requirements of a 15 Kw generator powered by a closed-cycle compound steam engine. Some of these fuels are seasonal in supply, e.g., rice hulls and straw, and are too bulky to stockpile. Some have other uses besides fuel -agricultural mulch, fertilizers, building materials, or animal feed. Some are concentrated geographically, for example coal in India and Colombia, where the cost of transporting coal into the villages is an effective deterrent to its widespread use. Wood is available in certain areas, as in the Indian State of Orissa or in southern Chile, but in general wood is either not available in the quantity required, or is too expensive.

6. The bio-gas generator which has been developed in India for animal dung offers a limited potential as an energy supply, and has the added advantage of producing a fertilizer residue. Family size units of 100 cubic foot daily capacity have been built and tested by the Indian Agricultural Research Institute. Gas production of this unit is sufficient for lighting (4-5 cubic feet of gas per hour for a gas lamp) and cooking (10 cubic feet of gas per hour per burner). At its current stage of development, however, the bio-gas unit is too expensive for the average villager.

7. Widespread distribution systems for diesel and gasoline fuels exist in both Latin America and India. Under these circumstances, reliable internal combustion engines would appear to be the most appropriate equipment for local energy generation. However, diesel power is usually too expensive both in terms of the ability to pay and existing rural electric rate structures. This is particularly true in India, where the price of high speed diesel fuel in rural areas ranges from 50 to 60 cents per U.S. gallon, reflecting the high tax designed to discourage consumption of imported petroleum fuels. It is less true in Colombia and Peru where domestically produced diesel fuel is considerably cheaper, ranging from 10 to 16 cents per U.S. gallon. The cost of diesel-generated power in India based on a 50 Kw unit operating at a 30 percent load factor using high speed diesel fuel at 42 cents per U.S. gallon approximates ten cents per kilowatt-hour. In Colombia the cost would be about six cents per kilowatt hour, with fuel at ten cents per U.S. gallon.

Figure I
Daily Fuel Requirements of a 15 Kw Generator Operating at a 30 Percent Load Factor

Plant	Fuel	HHV (btu/lb)	SFC (lbs/kwhr)	Plant Eff. (%)	Fuel Rate (lbs/day)
Diesel Electric	Diesel Oil	19,750	.75	23.1	80
Gasoline-Electric	Gasoline	20,750	1.11	14.8	120
Closed cycle, compound steam engine electric	Diesel Oil	19,750	1.15	15.0	125
	Bunker C Oil	18,000	1.27	15.0	140
	Coal	11,800	1.93	15.0	210
	Wood	8,500	2.68	15.0	290
	Agricultural Waste	7,500	3.04	15.0	330

HHV-Higher Heating Value; SFC-Specific Fuel Consumption.

8. The upland areas of Chile, Peru and Colombia in the Andes have many glacier-fed streams with a year-round hydroelectric potential of 50 to 500 Kw. Because of their steep gradients (150 to 300 feet per mile) these streams are a potential economical source of locally generated electricity. This resource has been exploited to only a limited extent for rural electrification and many excellent opportunities exist.

9. Wind-generated electricity offers few practical application opportunities in India or Latin America. At Alta Plano in upland Peru, there are sustained daytime winds. The north coast of Colombia also has low velocity (10-15 mph) sustained winds throughout the year. However, these regions also have readily-available gasoline and diesel fuels at prices so low that the generation of any useful level of electricity by wind power would be non-competitive. The most effective use of wind power, where available, would appear to be for pumping rather than for the generation of electrical power.

10. Solar power also appears impractical for near-future rural electrification. Substantial research and development work remains to be done to increase conversion efficiencies and to reduce equipment costs in order to compete with presently-available power generating equipment.

Utilization of Electrical Energy

11. Generally speaking, the on-site investigations of representative rural communities in India and Latin America revealed only limited opportunity for the productive application of electric energy supplied by small scale generating units.

12. Where irrigation is required, direct diesel pumping is, of course, more economical than electric pump sets supplied with electric energy from small scale generating units. Further, given the Indian land tenure pattern of three to four acres in many cases, it is difficult to justify either a diesel or an electric pump. The Indian government is making attempts to consolidate holdings, but in many parts of the country the size of the holdings is so small that even consolidated holdings will require common sharing of pumped water, an arrangement which has so far been extremely difficult to arrange to the satisfaction of the parties concerned. The social problem is the critical factor here.

13. There also appears to be very little potential for the productive use of electricity by small industry at the village level because the traditional industries -weaving, tanning, oil expelling, shoemaking, etc.- cannot begin to compete with the larger and more efficient units in towns and cities. Currently these village industries are economically marginal or sub-marginal, the daily income per Indian artisan ranging between Rs. 50 to Rs. 1.25, or ten to twenty five U.S. cents. Under those special circumstances where it is appropriate to perform certain processing operations at the village level, such as grain grinding or oil expelling in a village that lacks access to a market town, it would appear to be more economical to utilize the shaft power of an internal combustion engine directly rather than to convert shaft power to electric energy to power a small electric motor. For illumination it is usually less costly to utilize kerosene or gasoline-mantle lanterns than to use this same fuel to power a small scale engine-generator supplying electricity to an electric light bulb in the absence of other loads. Productive uses must be developed to achieve a minimum load factor to make electrification practical and economical.

14. Given the present limited opportunity for the productive application of electric energy, which works against the possibility of achieving an appreciable load factor, and given the favorable economics of direct shaft power as against electric energy for satisfying the principal existing requirements for power, it appears doubtful that the introduction of small-scale generating units can be justified at the village level, with the possible exception of small hydro units. This is not to say, of course, that power may not be a worthwhile social and political investment for purposes of improving rural amenities and avoiding dissidence. It is important to be clear with respect to the costs of providing such services, however, and in the absence of significant productive applications of electric energy in agriculture and small industry, to face up to the possibility that uneconomical highly-subsidized electric services may not prove to be permanent.

RURAL UTILIZATION OF POWER IN COLOMBIA AND INDIA

Electricity Utilization in Rural Colombia

15. Figure II presents data on the percentage of the rural population in Colombia with access to electric power. The data indicate that in 1960 approximately 23 percent of the rural population had no access to power, and that the bulk of the population with access to power were supplied by Class G plants (less than 100 Kw). Energy generated by these plants is used almost exclusively for illumination, and it is estimated that about two thirds of the total electricity generated by Class D-F plants (100 Kw-5000 Kw) is also used for lighting during a few hours of the early evening.

16. A review of load factor data for rural Colombia shows a rough correlation between load factor and the percentage of the rural population served, i.e., the greater the rural population served, the lower the load factor. For example in Giradot, 143 kilometers southwest of Bogota, the percentage of rural population in the area served by the local power company is only 8 percent, and the load factor is 40 percent. In Sahagun in Cordoba Dept., the rural population served is 85 percent, and the load factor 20 percent. The load factors of companies providing power from hydro facilities however

are much better than those of diesel generating companies; this is undoubtedly associated with the lower hydro rates, which are about one third of those charged by diesel-based companies. In any case there is a basic need to develop higher load factors.

Figure II
Rural Population with Access to Electric Power in 1960
(Unit: thousand persons)

	1960	Percent
Total Rural Population	8436	100
Est. Population without power	1973	23
Population served by B, C, D, E, F, Class plants	3014	36
Est. Population served by G Class plants (less than 100 Kw)	2734	33
Population with grid power	715	8

NOTE: Rural population is defined as persons residing in communities of less than 1600 inhabitants. The total 1960 rural and urban population of Colombia was 14,987.

17. Although electricity from small scale diesel and hydro generators had been available to a number of the rural communities surveyed for 30-40 years, there was a singular lack of application of power for purposes other than evening illumination. This indicates that the mere availability of limited power is insufficient to bring about productive applications. It also suggests that there has been little comprehension of alternative productive uses for power.

Electricity Utilization in Rural India

18. The degree of rural electrification differs substantially in various Indian states. Four states that have made much progress have electrified the following percentages of their towns and villages: Kerala (36%); Madras (32%); Andhra Pradesh (8%) and the Punjab (10%). Various factors have tended to facilitate rural electrification in these areas. In Kerala there is a relatively low proportion of smaller villages -only 12 percent of the villages have a population of less than 500, compared to the all-India average of two thirds. In Madras and Andhra Pradesh also, the typical village tends to be somewhat larger in size. Significant irrigation pumping loads in these areas supplement lighting loads, and, in addition the Madras, Kerala and Punjab power systems include a substantial proportion of low cost hydroelectric power.

19. It must be pointed out that even though these states are first electrifying the optimum villages from the standpoint of load building and use factors, rural electrification programs are still very heavily subsidized. In Madras,

for example, the State Electricity Board has estimated that the total annual subsidy to rural users in 1958, when only 4000 villages were electrified, was 1 1/2 crores of rupees, or 3 million U.S. dollars. This subsidy is estimated to total almost half the cost of supplying rural electricity, and is high in relation to the planned annual investment under the Third Five Year Plan of 6 crores of rupees to extend electricity to the remaining 8000 villages in Madras. Despite the subsidies and rates as low as 1.5 to 2.0 cents per kwhr, use factors are extremely low.

ELECTRIFICATION AND VIABLE RURAL DEVELOPMENT PROGRAMS

Indian Village Industry Programs

20. India's village industry development programs date back to the teachings of Ghandi and his followers, who created the All India Spinners Association and the All India Village Industries Association to revive and encourage traditional rural industries including the "charka" (hand spinning) and weaving industries. There were important social aspects of these efforts, and village self-sufficiency was a prime objective. A great deal of effort has gone into programs aimed at implementing these ideas. For example, in 1956, as part of a national small industry program that was having considerable impact in urban areas, 26 pilot projects were sanctioned in villages with the special aim of accelerating rural industrialization. Both new and traditional village industries were established. Of the 26 pilot projects, only 15 were really started, and of these only 9 were considered successful. The most successful in the final analysis were those involving traditional industries: namely, spinning and weaving. Even here the "successes were heavily subsidized." The evaluation of this effort made in 1959 stated: "The experience of these projects shows that where there is no electricity, and other facilities for the growth of small industries are lacking or are inadequate, and where the area is generally backward, a program of assistance to traditional and village industries can still be undertaken..."[a] It is generally recognized that the results of these efforts have not been encouraging. Industry has gravitated to those centers where it can operate most effectively, namely where raw materials, labor, power, transportation, capital, and markets are all available. During 1951-57, 47.2 percent of the new manufacturing enterprises in India were located in Class 1 cities of over 100,000, 19.3 percent in Class II and III cities (20,000-100,000 population), and 33.1 percent in towns of less than 20,000 population.[b]

The Village vs. the Market Town as Nodal Growth Center

21. In Colombia the typical "vereda" is a collection of huts, inhabited by 200 to 500 persons engaged in non-mechanized subsistance farming. The traditional grouping of people in a vereda is based on ready access to the small plots of land farmed and on social and security considerations, rather than on present-day economic factors. For marketing and the purchase of necessities,

[a] Report of the Study Team on Community Development Industrial Pilot Projects, Ministry of CommunityDevelopment and Cooperation, Government of India December 1959, p. 50

[b] Bredo, William: Industrial Development and Urban Growth with Particular Reference to Industrial Location, Paper 9, Seminar on Urbanization in India, University of California, Berkeley, California (1960.

the inhabitants of veredas travel to the nearby "pueblo" or market town, which usually constitutes the administrative and economic center of the larger "municipio" or county. Retail merchants and wholesale buyers of coffee, yucca, sugarcane and livestock typically operate in the market town. The principal church, schools and the circuit judge for the municipio are also located in the pueblo. The municipio areas surrounding these market towns vary widely in size and in the proportion of rural and urban inhabitants, although there is a rough correlation between the total population of a municipio and the number of pueblo inhabitants.

22. It would appear that the existing concentration of economic activities and population in the market towns offers the most promising economic base for rural industry, mid-way between major modern urban areas and small veredas. The pueblo also appears to offer promise of the greatest economic return for rural development programs associated with the productive utilization of electric energy. The generally ready access by villagers to the market center further suggests that economic and social improvements in the pueblos would have an impact on the rural inhabitants of the municipio in terms of higher employment, income and amenities. Possible types of small industry suitable for market towns in Colombia that can help build productive electric power loads include: agricultural product processing, construction materials, leather goods, woodworking, pottery and apparel. It cannot be assumed that any given industry would prove successful in any locality, of course, inasmuch as the availability of markets, raw materials, management, and capital will vary. The data in Figure III relate average power requirements to other characteristics of industries in various size categories ranging from 1 to 9 employees up to 25-50 employees.

Figure III
Electric Power Requirements for Small Scale Industries in Colombia - 1959

Category of Industrial Establishments by Number of Employees	Number of Industrial Establishments per Category in Colombia	Total Installed Horsepower per Category	Average Horsepower per Industrial Establishment	Average Kw Required per Industrial Establishment
1-9 empl.	6550	40,400	6.2	5
10-24 empl.	2326	47,400	20.4	15
25-49 empl.	835	54,700	65.5	50

Source:
Government of Colombia, Departmento Administrativo Nacional de Estadistica, via Banco Popular, Bogota (1962).

23. In India it is difficult to conceive of the small village as an initiator of new industry, although the traditional industries (khadi, coir, handlooms, etc.) have evolved over time within the village. Modern small industries imply a degree of specialization and urban training not available within the village. This training must be imported by either bringing entrepreneurs and skilled workers to the village or by selecting promising villages and training them. The Karve Committee, which helped pave the way for the small industry program in India, had this to say about the pattern of industrial decentralization.[c]

> "The pattern of industrial activity that should gradually emerge is that a group of villages having its natural industrial and urban centre. These small urban centres will be similarly related to bigger ones. Thus a pyramid of industry broad-based on a progressive rural economy will be built up. In such an organization small centres can experience a cooperative interest in the bigger ones, and these latter would develop a genuinely supporting instead of an exploitational relationship towards the smaller towns and the countryside."

24. This brief discussion highlights the fact that the issues of urban versus rural development, or centralized versus decentralized growth, and regional balance in development, are clouded by many complexities. In the meantime, economists, sociologists, and planners will have to do some "educated guessing." This kind of educated guessing was undertaken by a large number of high level officials and economists who attended a seminar on rural industrialization sponsored by the Ford Foundation in March 1960.[d] The main conclusion of this meeting seemed to be that industrial decentralization would at best mean decentralization from the very large urban centers toward the smaller towns and that rural industrialization could not be conceived of as a village goal, but as an area objective. Within given areas of rural India, nodal growth centers would provide a need and opportunity for clusters of small industries. It is around these clusters, probably located in market towns, that a foundation for rural industry might be established. Similar conclusions appear appropriate for the Latin American situation.

The Systems Development Approach

25. The preceding discussion suggests that there is a need for an approach to rural development that would consider the inter-relationship between the provision and productive utilization of electricity from the viewpoint of the systems analyst. The systems analyst would be concerned with an electrical energy supply system consisting of generation, transmission and distribution sub-systems, and an energy utilization system consisting of the agricultural production, small industry and consumption sectors of the rural economy.

[c] Report of Village and Small Scale Industry Committee, Planning Commission, Government of India, New Delhi (October 1955) p. 22

[d] Morse, Richard, Rural Industrialization in Economic Development, Seminar Report, the Ford Foundation, New Delhi, (April 16, 1960).

The type of generating system and the cost of delivered energy are obviously influenced by the characteristics of the load to be supplied and the utilization system. The "scale" problem is critical in identifying the various types of small industries and processes which are viable for rural areas. Electrification can only be planned in relation to the total rural development program. In anticipating and appraising the impact of energy on a newly electrified area, one must consider both the economic system and the social system. In fact, social factors may well override technical and economic considerations.

26. It is concluded that the market town offers the most promising site for rural electrification projects integrated with viable rural development programs. An effective electric load-building program must be provided to develop productive uses of electricity to achieve an economical load factor; the mere provision of electricity is insufficient. Small-scale (10-15 Kw) generators utilizing local fuels, wind or solar power do not appear to have significant practical application potential. The minimum size generator to be considered for a town of 2000-3000 population is 50.Kw, with additional capacity for growth and stand-by very desirable.

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